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Conventional Gravity Distribution
On-site Sewage Systems in Soil Type 1A
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For more information or additional copies of this report,
contact:

Office of Environmental Health & Safety
Wastewater Management Program
PO Box 47825
Olympia, WA 98504

Tel: 360-236-3062

Fax: 360-236-2261

WastewaterMgmt@doh.wa.gov

Mary Selecky
Secretary of Health
Washington State

Environmental Health

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Conventional Gravity Distribution
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Environmental Health Programs

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For more information or
additional copies of this report contact:

Office of Community Environmental Health Programs
Building 2, Thurston Airdustrial Center
PO Box 47826
Olympia, Washington 98504-7826

206-586-1249
SCAN 321-1249
FAX 206-664-3071

Bruce Miyahara
Secretary of Health

Special Acknowledgements

Ginny Stern
Office of Drinking Water Programs
Washington State Department of Health

Ed McCarthy Ph.c., P.E.
Shipiro & Associates
Seattle Washington

Dorothy Stoffel
Water Quality Programs
Washington State Department of Ecology

Tom Long
Office of Community Environmental Health Programs
Washington State Department of Health

Page Contents

1 Purpose

1 Format

2 Introduction

5 Limitations

6 Determining If Well Logs Are Representative
— Data Sources

7 Confined Aquifer Sites
— Site Description
— Site Evaluation

8 Unconfined and Semi-Confined Aquifer Sites
— Site Description
— Site Evaluation

9 Glossary

11 Bibliography

Design Guideline for Conventional Gravity Systems in Soil Type 1A

Purpose

The objective of this guideline is to advise those responsible for implementing requirements of the Washington State Administrative Code, Chapter 246-272, On-site Sewage Systems. Section 11501(2)(h) states that conventional gravity systems are not to be installed in Soil Type 1A. However, an exception may be permitted by the local health officer if sites satisfy all criteria listed in that section of the regulation. Use of this guideline is one of the requirements.

Conventional gravity drain fields are simpler to install and operate than some alternative treatment technologies. Unfortunately, gravity distribution is not appropriate for all sites, especially those classified as Soil Type 1A that are characterized as "very gravely coarse sand", or "extremely gravelly" soil profiles. A description of why these systems are inappropriate for these soil conditions is explained in detail later in the Introduction of this document. However, it is also recognized that under arid climate and deep soil conditions, adequate treatment can occur beneath a conventional gravity system if the site meets specific requirements. This guideline provides a method to determine if a site where Soil Type 1A has been identified in the upper 6 feet of soil horizon may be suitable for installing a conventional gravity system instead of a more complex alternative.

Format

This document begins by describing why conventional gravity on-site systems in Soil Type 1A raise health concerns. It is followed by the list of limiting criteria described by WAC 246-272-11501(2)(h) and purpose for imposing each restriction. Valuable information can be derived from well logs and well reports, so the guideline describes how to determine if data sufficiently represents conditions for site evaluation. Geologic settings provide a range of protection, some more than others. The general settings expected to be encountered are broadly classed according to the aquifer conditions, and minimum requirements for each are described. The ability to read a well log and perform simple math functions is necessary for determinations. Since information must be exchanged between two fields of interest, (on-site sewage and well drilling) a glossary is also included.

Introduction

Soil characteristics beneath the disposal component of conventional on-site wastewater treatment systems directly influence performance. Soil particles provide attachment surfaces for microbial biofilms that attenuate wastewater contaminants. Pore spaces between soil particles influence the availability of atmospheric oxygen for microbial respiration, and control the rate of liquid movement through the soil profile. Extremely fine textured soils do not transmit gases and liquids well. This translates into an inability to withstand sustained hydraulic loading, or a propensity for excessive soil clogging by bacterial growth, leading to overt failure of the drainfield. At the other end of the spectrum, extremely coarse textured soils transmit gases effectively, but liquid movement downward may be so rapid that insufficient treatment occurs as wastewater passes through the soil horizon.

The two major forces influencing liquid movement through soil are gravity and adhesion. In saturated soil, all the pores are filled and water moves downward by the force of gravity. In unsaturated soil, water movement is controlled mainly by adhesive flow due to surface tension between the water and soil particles that makes liquid move across each particle surface. Downward flow movement ceases once a film of uniform thickness has formed upon all the soil particles. When an additional input of water occurs, gravitational forces overcome adhesive forces, causing a pulse of flow downward through the soil. Afterwards, a film of liquid again remains on each particle. The adhesive force depends upon the amount of surface area per unit volume of soil. Finer soils present a large surface area, so they exert greater adhesive force than coarse soils therefore retain more water. This provides longer retention time for soil microbes to attenuate contaminants.

The amount of biomass in ecosystems is directly related to the amount of external energy supplied. Energy supplied to the microbial colony beneath the disposal component is supplied as nutrients (substrate) dissolved in septic tank effluent. The amount of active microbial colony necessary to utilize all the substrate depends upon the mass load of organic constituents in the effluent. The microbial colony is attached to soil particle surfaces as biofilms. Therefore the volume of soil occupied by the colony is related not only to the organic content of the wastewater but soil type as well. Finer grained soils present greater surface area for biomass attachment than coarse grained soil, so a higher microbial concentration is available to metabolize substrate in the wastewater per unit soil volume. Thus, for a given unit of time, with similar strength and volume of septic tank effluent, finer grained soils, by their nature of greater surface area, provide a greater concentration of microbial biomass for substrate metabolism than coarser grained soils.

A greater volume of coarse grained soil is required to provide the equivalent performance expectations of a fine grained soil. The presence of gravel further reduces particle surface availability for microbial attachment. Treatment performance is significantly impaired if high percentages of gravel or rock fragments occupy the soil volume. This soil condition is defined as "Soil Type 1A" by the On-Site Sewage Regulations Chapter 246-272-11001(2)(e) Table II, WAC. It is characterized by the USDA Soil Conservation Service classification

system as "very gravelly coarse sands containing greater than 35% gravel or coarse fragments, or extremely gravelly soils containing greater than 60% gravel or coarse fragments".

Coarse grained, gravelly soils exhibit higher permeability due to larger pore volume. For the reason of the large pore size, and much diminished soil particle surface area (fine textured soils, with considerably greater number of small soil particles compared to coarse grained soils, has much more soil particle surface area) the adhesive forces attainable are much less and easily overcome by gravitational forces. Since liquid passes through quicker, there is less contact time for the biomass to utilize substrate in the effluent. Since substrate remaining in the effluent is available at greater depth, microbial biofilms attach upon soil particles deeper in an attempt to gain full advantage of nutrients. If effluent substrate is not utilized completely before it reaches groundwater, attached microbial colonies can extend down through the profile to cause contamination. Effluent may even move rapidly enough through a Soil Type 1A profile to physically carry mobile pathogenic organisms down to unprotected groundwaters.

The rate at which a biomat develops at the soil interface upon the floor of an effluent distribution trench varies according to several factors. The most notable of these being wastewater temperature, strength and porosity of the supporting material. The clogging action by the biomat limits the rate at which effluent is released to the soil profile below. Therefore, it is an essential component that affects treatment performance. The highly permeable nature of some soil is not conducive to rapid development of a biomat. This makes conventional gravity effluent systems susceptible to poor performance due to localized hydraulic loading until a layer forms. In all soil types other than Soil Type 1A pressure distribution systems aid treatment performance by addressing the problem of localized hydraulic load. This is accomplished by spreading effluent as discrete doses over a wide area much like a sprinkler system. Since effluent is dosed periodically, localized saturated flow conditions are eliminated. This insures that the soil volume occupied by the microbial colony is maintained higher within the soil profile thus reducing potential for groundwater contamination.

In many areas of Washington State, shallow water tables (caused either by precipitation, as in Western Washington, or irrigation, as in Eastern Washington) or restrictive geologic conditions exist within six feet of ground surface. Since the trench of a conventional drainfield occupies the uppermost three feet of the soil horizon, treatment must occur in the three feet vertical separation remaining beneath the bottom of the drainfield trench down to the water table or restrictive layer.

Adequate and consistent treatment performance is extremely difficult to achieve in Soil Type 1A conditions. In Soil Type 1A, conventional pressure distribution systems alone do not provide adequate assurance that wastewater will be treated before contacting groundwater or restrictive layers. Public health protection must be assured by the use of systems meeting Treatment Standard 2 in most areas in Washington State with Soil Type 1A.

Regions with low recharge (precipitation + irrigation) present less potential for saturated flow

events beneath trenches of disposal components. Great depth of Type 1A soils with correspondingly deep aquifers and/or impervious geologic layers over vulnerable aquifers in these low rainfall settings also provide protection. Primarily, these three conditions occur together only east of the Cascade Mountain Range in Washington State.

This guideline for use of conventional gravity drainfield systems in Type 1A soils is based upon the concept that if the system is located in a region with minor recharge, sufficient soils exist at depth above groundwater, the "time of travel" for effluent to pass through the profile will alleviate potential contamination by pathogenic organism "die-off" and substrate metabolism.

The remainder of this document provides a means to identify sites where low recharge, adequate soil depth and geologic protection beneath conventional gravity systems in Type 1A soils minimize risk of contaminating groundwater. There are several sections: Limitations; Determining if Well Logs Are Representative; Confined Aquifer Sites; and, Unconfined and Semi-Confined Aquifer Sites.

Specific requirements, or criteria, for site approval are provided in the Limitations section. All six of the listed conditions must be met. If any of the requirements are not met, the site with Soil Type 1A will not qualify for an exemption allowing installation of a conventional gravity flow septic tank and drainfield system.

The section following exemption criteria advises those who are responsible for deciding if well log information submitted for the location is satisfactory for an accurate determination of geologic conditions. The next two sections then describe, and establish standards that must be met for the two aquifer classifications.

If the site under consideration meets all limiting criteria, and the local health officer is satisfied that data submitted is adequate according to this guideline, then evaluation of the geologic setting can then proceed. Once the health officer has determined that requirements described for the aquifer setting beneath the site are sufficient, approval can be granted for design and installation of a conventional gravity flow septic tank and drainfield system.

Limitations

A series of restrictions were placed upon granting exception to the requirement that a conventional gravity system not be placed in Soil Type 1A by On-Site Sewage System Regulations, Chapter 246-272 WAC. This section of the guideline provides an explanation for each restriction to clarify intent. In order for a site to qualify for an exemption, all of the conditions listed must be met before a conventional gravity on-site system may be designed for Soil Type 1A:

- ▶ ***System must only serve a single family residence***
This insures that wastewater loading will be no greater than typical domestic strength and be intermittently dosed. As discussed in the introduction, size of the microbial colony necessary to metabolize nutrient substrate in wastewater effluent is related to nutrient load or sewage strength. The hydraulic loading and strength of wastewater from a single family residence is relatively predictable. This limitation reduces risk that excess loading by either factor will cause microbial contamination to extend extremely deep through the soil profile.
- ▶ ***Lot size must be greater than 2.5 acres***
A hydro-geologic report for each site to accurately determine groundwater flow direction would be difficult to generate and expensive. This lot size minimizes potential impact to groundwater flowing toward, and under, adjoining properties, reducing potential cumulative affects of incomplete contaminate attenuation.
- ▶ ***Annual precipitation plus irrigation must be less than 25 inches per year***
When soil becomes saturated during periodic precipitation or irrigation events, it accelerates contaminant movement during each episode. Low recharge rates allow greater time for contaminant attenuation.
- ▶ ***Must be located outside all delineated "Areas of Special Concern" defined by Chapter 246-272-21501 WAC On-site Sewage Systems***
It would be inappropriate to allow less conservative design measures in vulnerable areas that have been identified through public process as requiring higher on-site sewage treatment performance to protect public health.
- ▶ ***Must be located outside the 12 county Puget Sound Water Quality Authority region.***
The names of these counties are listed in the glossary of this guideline. Even though the annual precipitation in Western Washington generally exceeds 25 inches per year, some low-rainfall micro-climates exist. This limitation was included in On-site Sewage System Regulations WAC 246-272 in recognition that it is unlikely that Puget Sound region sites could meet both adequate soil depth and low rainfall requirements.

► ***Must provide a readable, representative well log***

The health officer must be satisfied that information being presented accurately portrays the geologic condition beneath a proposed system. The health officer may need to apply local knowledge to determine if data collected within the area is sufficient if a well log is not available for an individual site under evaluation. If the data for the area is insufficient, a drinking water well may need to be drilled on the property, before the designer or health officer can determine if the site is suitable for a conventional gravity system. Guidance regarding the appropriateness of data will be provided by this guideline.

A range of minimum site conditions are described later by this document, so site evaluation using this guideline necessitates accurate information regarding geologic conditions to be drawn from well logs or well reports. Well log readability may be deemed unsuitable by health officers if information presented to them is inaccurate, incomplete or does not provide sufficient detail.

Determining if Well Logs Are Representative

Well log readability and quality is subject to review and approval by the local health officer.

Data Sources

Evidence of appropriate hydro-geologic conditions can be determined by using any one or more of the following data sources:

- A well log for a well on the property where the on-site system will be installed;
- Representative well logs for wells on immediately adjacent properties;
- Well logs for nearby domestic/public water supply wells;
- A collection of area water well logs or boring logs (at least 4) for area encompassing the proposed site; or
- A hydro-geologic report and/or engineering report documenting ground water and subsurface conditions at the site.

Confined Aquifer Sites

Site Description

An intact aquatard (semi-permeable or impermeable geologic layer) not only provides a physical barrier, but by confining an aquifer can maintain a positive pressure that keeps contaminants from entering it. Evidence that the aquatard is intact can be determined by measuring the pressure head of the vulnerable aquifer. Vulnerable aquifers are those that are currently used or expected to be used in the future as a source of drinking water.

A minimum soil depth above the aquatard is also required to meet requirements. The purpose for this is twofold. First, an unconfined aquifer may be perched above the confining layer. Since this "perched" water is likely to surface at some point down-gradient, a minimum soil depth reduces the likelihood that it will surface nearby without sufficient travel time to disperse or attenuate contaminants. The second reason is that the aquatard could be fractured down-gradient which could allow perched waters to mingle with those of the confined aquifer.

Site Evaluation

Geologic materials described by well logs are generally classified with less detail and in larger increments, than surface soil classifications. This guideline addresses material descriptions expected to be encountered when evaluating well log reports, and provides a minimum depth for each. To determine if the geologic conditions protecting a "confined aquifer" are sufficient to install a conventional gravity system, the site should demonstrate all three of the following characteristics:

1. The depth of soil down to the "aquatard" (confining layer) should be 25 feet or greater.
2. The "aquatard" thickness should be 5 feet or greater.
Descriptions of the "aquatard" material may include any of the following terms: Hardpan, Silt, Clay, Till, Massive bedrock (consolidated, non-weathered, non-fractured).
3. The pressure head of the vulnerable aquifer should be 20 feet or greater.
The pressure head is the difference in elevation measured in feet, between the static water level in a well and top of the confining layer overlying an aquifer.

Unconfined and Semi-Confined Aquifer Sites

Site Description

An unconfined aquifer is a situation where groundwater flows over geologic material without semi-permeable or impervious layers above it. A semi-confined aquifer is one where groundwater flows between geologic confining layers, but the overlying geologic formation is relatively thin or has a low pressure head. An unconfined or semi-confined aquifer situation is identified if any of the following descriptions apply:

- ▶ The vulnerable aquifer is not confined by an aquatard,
- ▶ The aquatard is less than 5 feet thick, or
- ▶ The piezometric pressure head of a confined aquifer is less than 20 feet.

Site Evaluation

Geologic materials described by well logs are generally classified with less detail and in larger increments, than surface soil classifications. This guideline addresses material descriptions expected to be encountered when evaluating well log reports, and provides a minimum depth for each. A site is suitable for a conventional gravity on-site system if the minimum cumulative depth of material measured from the ground surface down to the top of the water table meets the following requirements:

Descriptive Well Log Entry

Cumulative Depth from Ground Level Down to Top of Water Table

Sand, loam, silt or clay as predominant materials but doesn't include the following terms: gravel, cobbles, or pebbles.

30 feet or greater

Coarse sand.

35 feet or greater

Sand with secondary characteristics described as pebbles, or small gravel (not cobbles, or coarse gravel).

50 feet or greater

Cobble, coarse gravel, boulders.

Not allowed to be included for calculations

- ☐ If uniform geologic conditions exist throughout the entire profile down to the water table, the depth must equal or exceed the minimum depth requirement assigned by this guideline for the material listed by the well log.
- ☐ If the profile comprises multiple layers, the minimum depth requirement is determined as if the profile were uniform, but the minimum depth must equal or exceed the most stringent depth requirement assigned by this guideline for any soil material listed by the well log.

Glossary

Adhesion The physical attraction between two dissimilar substances.

Aquatard A semi-permeable (low porosity) or impermeable geologic layer that impedes vertical movement of groundwater and acts as a confining layer to an aquifer. It may include the following materials: hardpan, silt, clay, till, or massive bedrock.

Aquifer A geologic formation, group of formations, or part of a formation capable of yielding a significant amount of groundwater to wells or springs.

Biofilm Facultative microbial organisms such as bacteria and fungi that attach upon wetted surfaces where sufficient nutrient and dissolved or molecular oxygen is available to support metabolic activity.

Blomass The colony of microorganisms that attenuate wastewater contaminants. The soil volume necessary to support the colony is dependent upon the surface area presented by soil particles in the soil profile for attached growth, oxygen availability and wastewater strength.

Blomat The layer of active and inactive microbes that accumulates upon the infiltration surface at the bottom of effluent distribution trenches. The "clogging" action limits the hydraulic loading rate at which effluent can pass to the soil below.

Contamination Is an impairment of natural groundwater quality by biological, chemical, or physical materials which lower the water quality to a degree which creates a potential hazard to the environment, public health, or interferes with a beneficial use.

Conventional Gravity System Is an on-site sewage system consisting of a septic tank and a subsurface soil absorption system (SSAS) with gravity distribution of the effluent. A SSAS means a system of trenches three feet or less in width, or beds between three and ten feet in width, containing distribution pipe within a layer of clean gravel designed and installed in original undisturbed soil for the purpose of receiving septic tank effluent and transmitting it into the soil.

Impermeable Is a descriptive term for earth materials which have a texture or structure that does not permit fluids to perceptibly move into or through its pores or interstices.

Mass Load Is a critical waste loading parameter addressed by design of wastewater treatment systems. The mass load for wastewater constituents is usually expressed in kilograms/day, or as grams/capita/day. Mass loading is derived by the following equation if the flow rate is expressed in litres/day:
$$\text{Mass loading kg/day} = (\text{Concentration, mg/L}) \times (\text{Flow rate, L/d}) \div (10^6 \text{ mg/kg})$$

An excellent information source regarding typical mass loading expectations of various constituents in typical residential wastewater can be found in Table 4-3, EPA Design Manual for On-site Wastewater Treatment and Disposal Systems EPA 625/1-80-012.

Metabolism The complex of chemical and physical processes necessary to maintain life.

Permeability The ease with which porous materials allow liquid or gaseous fluids to flow through them. Usually termed hydraulic conductivity, expressed as cm/sec.

Pressure Head Pressure head is the difference in elevation measured in feet, between the static water level in a well and top of the confining layer of an aquifer.

Puget Sound Water Quality Authority

12 County Region This refers to 12 health departments/districts in western Washington State that are affected by the Puget Sound Water Quality Authority that include; Bellingham-Whatcom, Bremerton-Kitsap, Clallam, Island, Jefferson, Mason, San Juan, Seattle-King, Skagit, Snohomish, Tacoma-Pierce, and Thurston.

Recharge The amount of water that reaches groundwater via infiltration and percolation after application to the land surface. The net amount of recharge to groundwater is a function of precipitation and irrigation after subtracting losses due to effects of evaporation, transpiration and run-off. Transpiration losses during subsurface flow tend to be seasonal and range between 10 to 20 percent of the total water budget. A useful source for precipitation data can be found in a series of publications available at the reference section of local libraries called "Washington Climate For These Counties" by the Cooperative Extension Service.

Soil Type 1A Soil type 1A classification of earth particles and coarse fragments that are described in the On-site Sewage System Regulation chapter 246-272-11001(2)(e) of the Washington Administrative Code as; Very gravelly coarse sands or coarser, and all extremely gravelly soils. "Very gravelly" is soil that contains >35% and <60% gravel and coarse fragments by volume. "Extremely gravelly" is soil that contains >60% gravel and coarse fragments by volume.

Static water level The vertical distance from the surface of the ground to the water level in the well when the water level is not effected by pumping or free flow.

Substrate The constituents in wastewater such as dissolved/molecular oxygen and nutrients that supply metabolic requirements of soil biota.

Vulnerable Aquifer A water bearing formation being used as a current or future drinking water supply with a propensity for contamination from surface sources.

Water Table Is the upper surface of the ground water, whether permanent or seasonal.

Well Any excavation that is drilled, cored, bored, washed, driven, dug, jetted or otherwise constructed when the intended use is for the location, diversion, artificial recharge or withdrawal of groundwater.

Well log Reports that describe well location, land surface datum, well identification number, diameter, and depth. It also normally provides graphic depiction of depth, thickness, and character of each bed, stratum or formation penetrated by the well. This information is available from "well reports" submitted to the Washington State Department of Ecology following well construction for certification under chapter 173-160-050(3).

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